THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

The Lehigh Tunnel, a horseshoe-shaped opening in a ridge of the Blue Mountains in Lehigh and Carbon Counties, Pennsylvania, is a part of the northeastern extension of the Pennsylvania Turnpike. Its overall length, including the cut and cover sections, is 4,417 ft. The excavated section between pay lines was 33 ft. 6 in. wide and 27 ft. 7 in. high.

Soon after the start of driving a heading from the south end, unstable slate and shale formations broke loose and tons of material cascaded over the portal opening, damaging equipment and materials, and sealing the tunnel.

The greater portion of the bore was driven from the north end, to take advantage of a 2.5 per cent grade. The completed project, scheduled to finish in December, 1956, will provide motorists with a two-lane tunnel 28 ft. 10 in. wide and 15 ft. 4 in. high.

A description of the methods used to advance the headings on this job is presented in the article beginning on page 165.

• • •

The Jos. J. Griesemer Quarry, located about a mile east of Springfield, Missouri, has supplied, and will continue to supply, millions of tons of crushed and prepared limestone for use on highway and allied construction projects. The quarry was opened in 1947, and operations were carried on as an open-face quarry.

In 1955, operating methods were changed to underground mining. Griesemer crews drove four tunnels, or drifts, each 50 ft. wide and 25 ft. high. This method provided a minimum ledge of solid rock above the tunnels, measuring 25 ft. thick. As tunnels were advanced, 30 by 30-ft. pillars were left, with cuts made to the right and left of each pillar and connected in the conventional room-and-pillar system of mining. This provided working faces 50 ft. wide and 25 ft. high.

The article beginning on page 172 describes the operating details that make possible the maintenance of a 200-ton-per-hour production schedule.

• • •

Louis R. Perini, president of B. Perini & Sons, and Guy F. Atkinson, board chairman of Guy F. Atkinson Company, have been chosen to receive the Moles awards for 1957, for outstanding contributions to construction progress.

For more details, please turn to page 180.

• • •

Awards of Sentinels of Safety trophies and flags highlighted ceremonies at four mining properties in widely separated parts of the country. Company officials and invited guests paid tributes to the mine employes at Alabama By-Products Corporation in Alabama, Warner Company in Pennsylvania, and Pickands Mather & Company in Minnesota.

Brief descriptions of the ceremony programs are given in the article on page 181.

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

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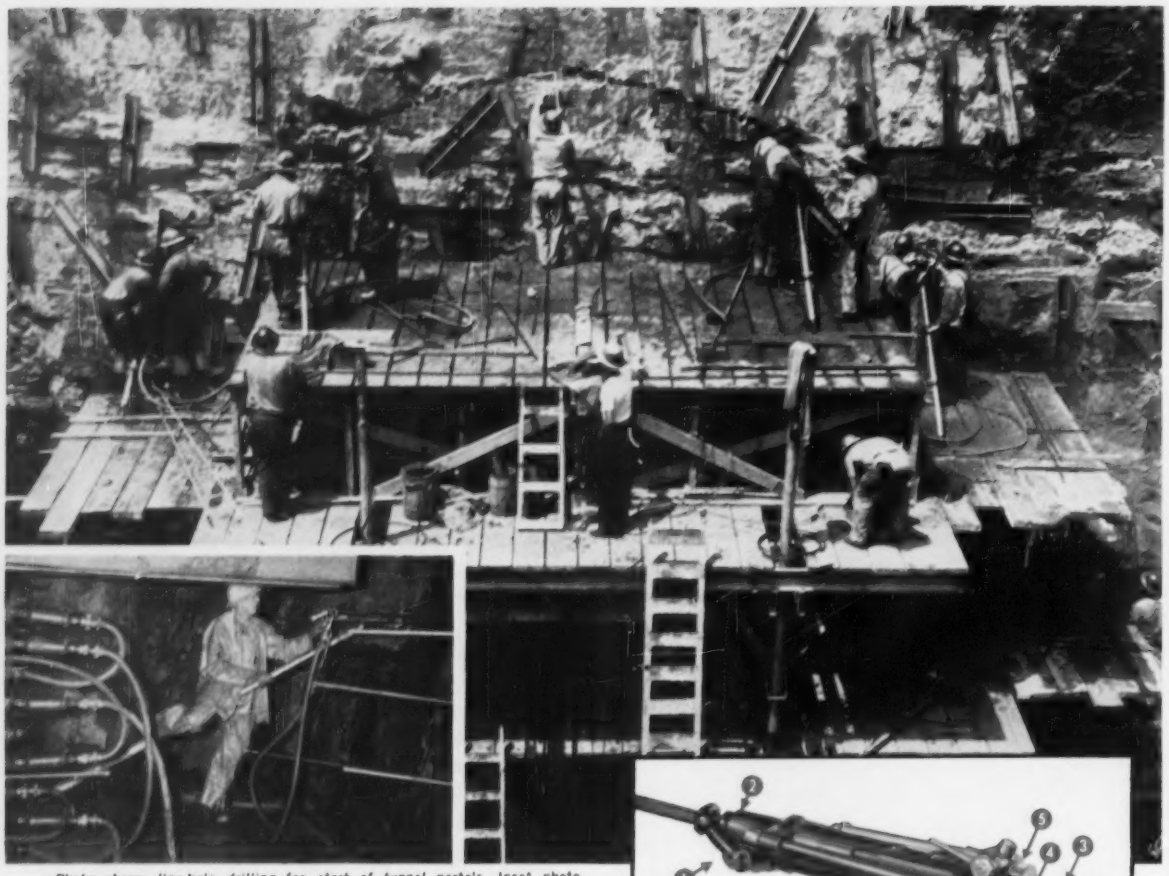

Photo shows line-hole drilling for start of tunnel portals. Inset photo shows close up of Jackdrill in action.

I-R JACKDRILLS DROVE NEW LINCOLN TUNNEL APPROACH

USING a top heading method and Ingersoll-Rand Jackdrills, the western approach to the new Lincoln Tunnel tube was driven through 700 ft. of rock with no delays and with the drilling synchronized to the mucking cycle.

Up to eight lightweight Jackdrills with air-leg feeds were used at the same time on the jumbo. Manifolding of air and water simplified shifting of the drills. The 115 holes for each shot were drilled 15 ft. deep, using 1⅜" Carset Jackbits and only one steel change.

This is another example of the versatility and ease of operation that have made I-R Jackdrills first choice with owners and operators alike, on mining and tunneling jobs all over the country. With the improved features of the new model JR38-B; the I-R Jackdrill will set still higher standards of performance and economy. Ask your I-R representative for complete details.

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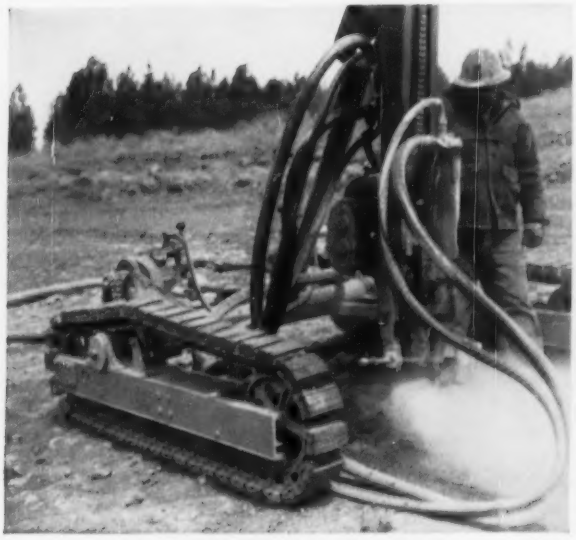

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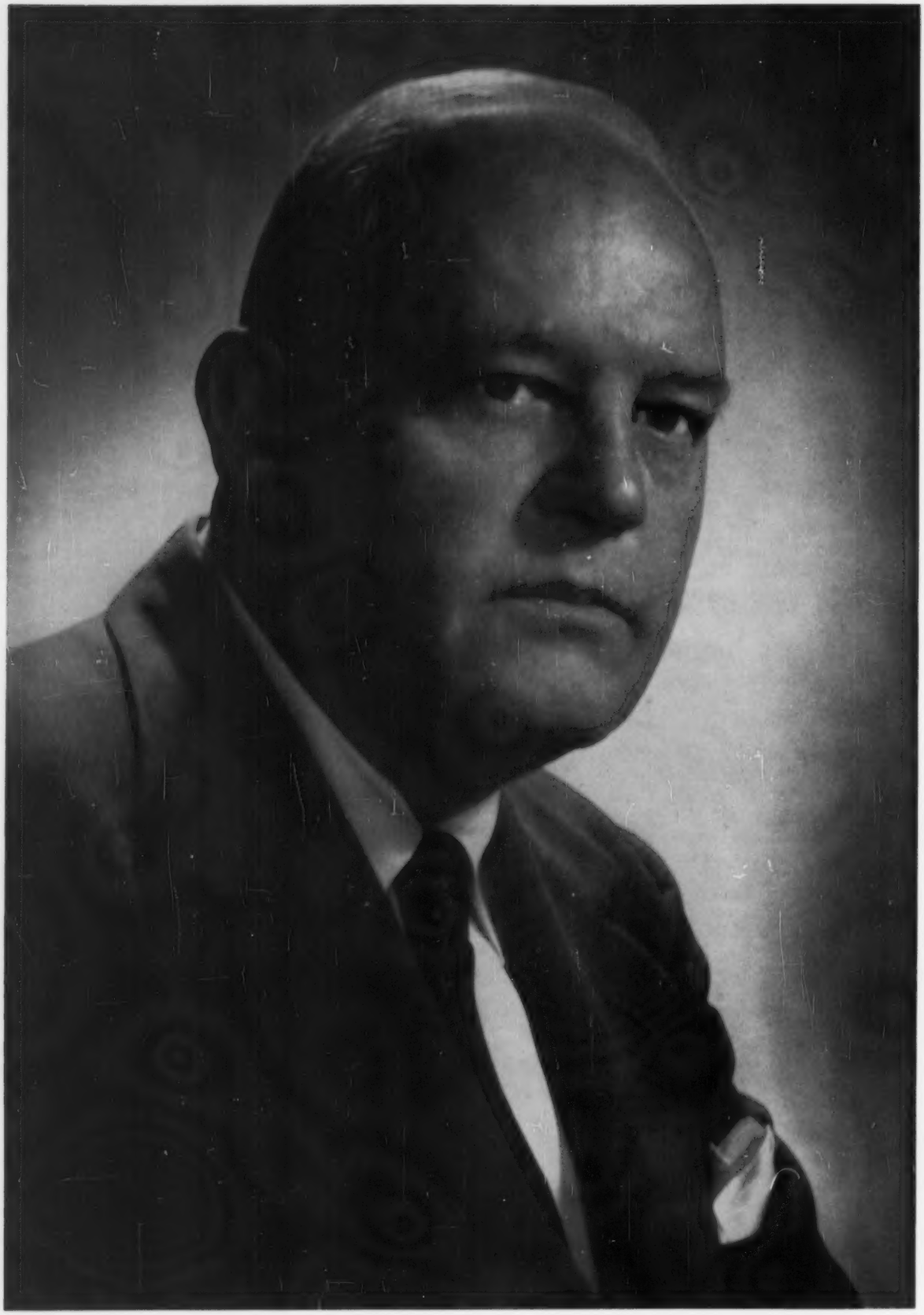


JOHN RICE, JR.

John Rice, Jr.

VICE PRESIDENT

THE GENERAL CRUSHED STONE COMPANY

A Biography

JOHN RICE, JR., vice president and a director of The General Crushed Stone Company, is a soft-spoken, understanding man who inspires cooperation and loyalty among those with whom he is associated. His career offers another example of the rewards that come from early devotion and consistent application of natural abilities to one field of endeavor. His service to the crushed stone industry has won him a place in the affection and esteem of fellow members of the industry.

John, as his friends and associates know him, was born in Easton, Northampton County, Pennsylvania, June 18, 1903, the son of John and Carrie Arndt (Drake) Rice. His father, a graduate of The Hill School and of Yale Sheffield Scientific School in the class of 1885, organized The General Crushed Stone Company in 1900. For many years, he served as president and chairman of its board of directors. Also, he was president and board chairman of Easton Trust Company. We were privileged to publish the biography of John Rice, Sr., in our January, 1924, issue.

After attending the public schools in Easton, John followed in his father's footsteps by completing his formal education at The Hill School in 1921 and at Yale University in the class of 1925S. While at the university, he was honored by election to memberships in the Sigma Chapter of Delta Psi fraternity and the St. Anthony Club.

On July 1, 1924, John went to work in the quarries of The General Crushed Stone Company. For three years he handled a variety of jobs, including a year as timekeeper at two quarry properties. He then was assigned to the company's office at Rochester, New York, where, for two years, he was a member of the sales department. His next move was to the company's home office in Easton to take over the duties of purchasing agent.

John's experience in the company's operations, sales, and purchases led to his appointment as vice president in charge of sales, transportation, and the bituminous-concrete division, and as a director of the company in 1931, the positions he holds today.

During World War II, John's associates in the crushed stone industry elected him president of the Pennsylvania Stone Producers Association; he continued in this office for four years, and, currently, is a director of the association. Over a long period of years, he has been a director of the New York State Crushed Stone Association; at one time, he served as vice president of the organization.

At present, he is a member of the Joint Technical Committee representing the New York State Crushed Stone Association and the New York Department of Public Works. He is also a director of the Bituminous Concrete Association of Pennsylvania and of Easton Trust Company.

John Rice, Jr., married Rebecca Adams on October 10, 1931, at Easton, Pennsylvania. They have one daughter, Virginia, a 1956 graduate of Smith College. The family home is at Four Oaks, Hillside Avenue, in Easton.

John's club affiliations include the Yale and St. Anthony in New York City, and the Pomfret and the Country of Northampton County in Easton. He is a ten-year member of the Scotch-Irish Society in Pennsylvania and a member of its Council. He is also a member of the Porcupine Club at Nassau in the Bahamas, where he has vacationed for the past twenty years.

Like many successful businessmen, John's principal hobby is his work. However, he does find time to relax from the pressure of his many responsibilities by beautifying with hundreds of dogwood and other varieties of trees, shrubbery, and flowers his picturesque hillside property overlooking Easton, and in deep-sea fishing expeditions off the coasts of Florida and Nassau with his friends.

Editorial

☆ HAPPY NEW YEAR ☆

The members of the editorial staff of THE EXPLOSIVES ENGINEER extend holiday greetings to our readers, with the sincere wish that you have a Happy New Year.

Business Uptrend Forecast

The consensus among economists and forecasters is that business activity in 1957 will show a moderate gain over 1956. A continuing rise in production volume in most basic commodities, record employment, and further wage increases indicate a sustained uptrend in our economy.

Highway Construction

The Federal-Aid Highway Act of 1956 spearheads the greatest highway-construction and -improvement program in history. It will provide a 41,000-mile network of modern highways connecting 48 states, linking 209 cities of more than 50,000 population. Approximately 755,000 miles of roadways are eligible for Federal aid under the Act. This multibillion-dollar, 13-year program presents the greatest challenge that highway officials and engineers have ever had to face. It also poses serious problems for manufacturers of materials and equipment.

Construction costs show a continuing upward trend. Higher prices are tagged to materials, equipment, and labor in practically every category. The situation demands careful examination of all facets involved in doing construction work by contract, especially checkups of operating methods and techniques, as well as equipment and materials.

All of the above factors focus attention on the dates January 28 through February 2, when the American Road Builders Association Convention and Road Show will be held in Chicago's International Amphitheater.

More than 200 manufacturers of road-building equipment, materials, and supplies will exhibit their products on 300,000 sq. ft. of exhibit area inside the world's largest indoor heated auditorium. Representatives of manufacturers will be on hand to answer questions. The mammoth show, the first since 1948, will attract visitors from every section of the United States and many foreign lands.

Select Explosives With Care

Throughout the nation, thousands of pounds of industrial explosives are used every working day in mines and quarries, on heavy-construction projects, and in seismic exploration. The cost of the explosives is relatively small in relation to the work done. But the fact that many other items of cost depend upon the results obtained from primary blasts should be sufficient reason for operators to insist that the buying, and using, of explosives for industrial purposes be done with deliberation and care.

Companies that manufacture explosives are continually on the alert for ways and means of improving their products. Millions of dollars and untold hours of intensive scientific effort have brought fixed explosives to their present high rates of effectiveness and economy. With never-ending programs of research, supplemented by field work of explosives engineers, manufacturers will continue to improve the effectiveness of industrial explosives.

Every operator should investigate opportunities for effecting economies. Explosives manufacturers have available trained representatives to help in analyzing drilling and blasting procedures, and in selecting and supplying the explosives best-suited to the work to be done. You will find it worthwhile to consult with them.

Help Eliminate Accidents

In 1925, the Bureau of Mines, then a division of the Department of Commerce with Herbert Hoover as the secretary, inaugurated the National Safety Competition, in cooperation with THE EXPLOSIVES ENGINEER. During the past 31 years, the statistics compiled show that the average mine or quarry that participated in the competition had a better safety record than the average mine or quarry not enrolled in the competition.

In 1955, the results of the contest show new low records established in the number of disabling injuries, and in both the injury-frequency and injury-severity rates. Also, 211 of the 529 plants enrolled operated a full year without a lost-time injury. This represents 40 per cent of the total enrollment with perfect safety records.

These accomplishments offer conclusive evidence that well-planned, well-directed safety programs, adequately supported by management personnel, pay big dividends to both employes and stockholders. Safe operations are profitable operations.

The National Safety Competition begins each year on January 1 and ends on December 31. We strongly recommend that you enroll your mine or quarry in the 1957 contest. Write today to the Accident Analysis Branch, U. S. Bureau of Mines, Washington 25, D. C., for a copy of the rules of the competition and an application form. Start the new year by joining this nationwide crusade for safe operations in the mineral industry.

UNSUPPORTED SECTION: This view of the Lehigh Tunnel from the north portal shows a section of unsupported roof and the 48-in. airline at the left. The completed project will provide a two-lane vehicular tunnel through a ridge of the Blue Mountains.

THE LEHIGH TUNNEL

Lipsett, Inc., drives two-lane highway tunnel through variable formations in a ridge of the Blue Mountains in northeastern Pennsylvania

R. L. OWENS*

THE Pennsylvania Turnpike Commission received bids on February 23, 1955, for the construction of the Lehigh Tunnel, Section 36 DE, part of the northeastern extension of the Pennsylvania Turnpike in Lehigh and Carbon Counties. When the bids had been opened and read by Turnpike officials, it was found the low bid was submitted by Lipsett, Inc., of New York City. The award was made in March, 1955, and work was started in September, 1955.

The specifications called for a two-lane vehicular tunnel to be driven through a ridge of the Blue Mountains, which bound Washington Township of Lehigh County to the south and East Penn Township of Carbon County to the north. The excavated section of the horseshoe-shaped opening between pay lines was 33 ft. 6 in. wide by 27 ft. 7 in. high.

The overall length of the tunnel, including the cut and cover sections, is 4,417 ft. However, the distance from rock portal to rock portal is 4,135 ft. About 88 per cent, or 3,644 ft., of the tunnel was driven from the north end and 491 ft. from the south end.

Geological Studies

Prior to advertising for bids on this project, extensive subsurface explorations were made by drilling 22 vertical core borings in the portal areas. Thirteen were drilled in the approach cut

*Hercules Powder Company
Hazleton, Pennsylvania

and south portal area, and nine were drilled at the north portal area. To determine the top of sound rock adjacent to the portal, four other borings were made east and west of the north portal area.

In addition, two horizontal core borings were made through the mountain above in an approximate line with the tunnel. These two bore holes were from the south and north, 1,334 ft. and 1,980 ft. in length, respectively.

Subsequent interpretation of the cores indicated four major rock formations to be encountered in tunneling through the mountain. The rock strata are classed, generally, as sedimentary in origin and were deposited in the Ordovician and Silurian geological periods. The formations dip to the south, varying from 30 degrees at the north to 45 degrees at the south. Both portals were driven in shale: the Martinsburg formation at the south end and the Bloomsburg formation at the north end. Approximately 3,000 ft. of tunnel were driven in the Clinton formation and about 600 ft. in the Tuscarora formation.

South Portal

Soon after the heading was begun, considerable difficulty was encountered because of unstable slate and shale in the Martinsburg formation. The contractor, limited to 4 and 5-ft. rounds, found it necessary to place steel sets at 4-ft. spacings. When the heading had advanced about 80 ft., an external slide along a bedding plane, caused by the lubricating action of water, sent tons of material cascading over the portal opening, sealing the tunnel, and tearing a number of steel sets that had been erected in the cut and cover area. Subsequently, the condition was alleviated by extending the benches and flattening the slopes above and around the tunnel entrance. In all, 525,000 cu. yd. of material were removed at the south portal. By comparison, the excavation of the tunnel bore amounted to 132,000 cu. yd.

When work was resumed in the

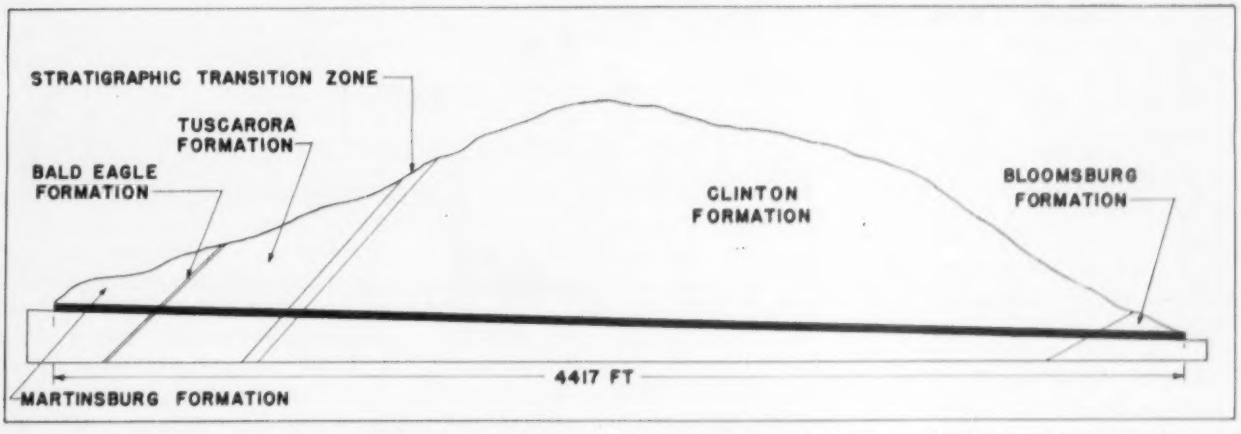
TWO-DECK JUMBO: Drilling a round of blast holes and loading the explosives charges in the full face of the tunnel heading were done from this steel frame two-deck jumbo.

heading, it was evident that the steel sets were under stress and it was necessary to pour the concrete lining up to the face. Also, a top heading, large enough to accommodate the arch members of the steel sets, was driven until solid rock in the Tuscarora formation was reached, a distance of about 200 ft. Except for an occasional plug hole, little blasting was required. Paving breakers were used to loosen the rock at the heading, and it was hand-mucked to a conveyor that carried the material to the bench face. A ¾-cu. yd. Lorain easily loaded the material into 12-cu. yd. Euclid trucks. The steel sets were placed at 2-ft. centers and gunited.

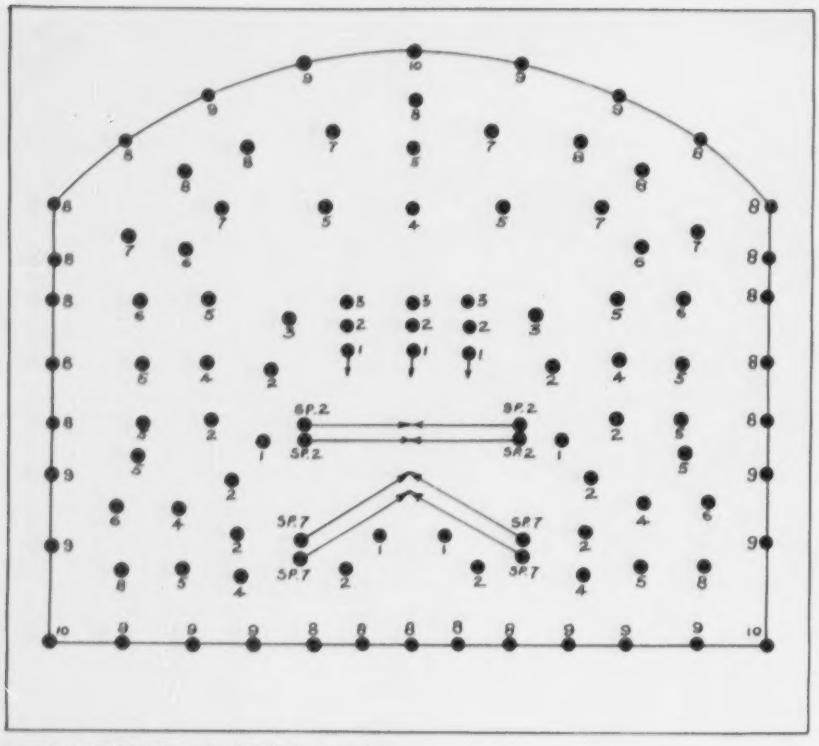
When the harder Tuscarora formation was reached, a three-level jumbo was employed to drill a full-heading round. Drilling was with 12 to 13 Ingersoll-Rand jack drills, Model JR-38A, with ⅞-in. Hex. steel, and 1¾-in.-diameter Carset bits. An average round at this point consisted of 130 to 140 holes, 8 to 10 ft. deep, loaded with approximately 800 to 850 lb. of Hercules® Gelatin Extra 60% dynamite primed with Hercules® No Vent® Delay Electric Blasting Caps with 16-ft. leg wires, No. 1 through No. 10 periods of delay. The leg wires of the caps were connected to two parallel No. 16 bare copper bus wires, with the electric current for firing the round applied at both ends. Blasts were fired from 440-volt a.c. firing switches, located outside the tunnel. The blasts averaged approximately 31 cu. yd. of material per lineal foot of tunnel.

After mucking operations were com-

LOADING EXPLOSIVES CHARGES: Two of the crew load explosives charges in the bottom holes of the tunnel heading. The round required 800 to 850 lb. of Hercules Gelatin Extra 60% dynamite primed with delay electric blasting caps.



PROFILE OF TUNNEL: The various geological formations through which the tunnel had to be driven are indicated in this diagram. The tunnel floor descends slightly from the south to the north portal.



TYPICAL ROUND: The black dots in the diagram show the location of the drill holes, and the numbers indicate the order of firing the blast. All holes were 15 ft. deep excepting the cut holes, which were 18 ft.

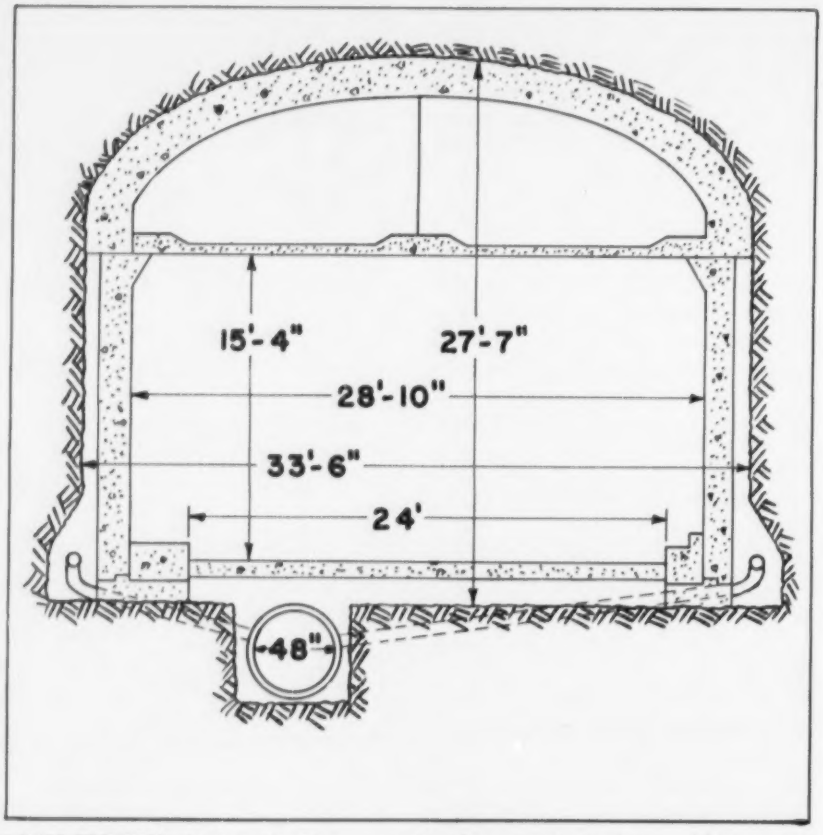
pleted, the jumbo was moved back to the face with a tractor and steel sets were placed, using two utility air hoists located on the top deck of the jumbo. Air was supplied by two portable Ingersoll-Rand Gyro-Flo compressors, 600-c.f.m. and 315-c.f.m. capacity.

North Portal

Taking advantage of a 2.5 per cent grade, the contractor drove the greater portion of the tunnel from the north end. In comparison with the south heading, little difficulty was encountered despite occasional water-bearing faulted zones in both the Clinton and Tuscarora formations. With the exception of a section about 420 ft. in length, steel sets were carried throughout the entire length of the north bore on account of these small local fracture zones. A two-deck steel frame jumbo, similar to the one at the south portal, was utilized to drive the heading full face. The original frame was constructed by Robert S. Mayo, of Lancaster, Pennsylvania; however, because of damage sustained by the constant hammering of boulders from scaling operations, it had to be replaced by one built on the job by the contractor. The front end is equipped with wheels, and the unit is moved with a tractor by means of a pin-type coupling mounted on a crossarm. The crossarm, as well as the interior wing decks, is hinged to permit passage of trucks and shovel.

Mucking was done by a Bucyrus-Erie 38B 1½-cu. yd. electric-powered shovel with a cut-down boom and dipper stick. Diesel Euclid dump trucks, 12-cu. yd. capacity and equipped with air scrubbers, were turned on a slick sheet with an Ingersoll-Rand air hoist. The sheet was carried about 200 ft. from the face. The material was transported to a fill area immediately north of the tunnel entrance.

The major portion of the tunnel was driven using a 10-ft. round with a complete cycle requiring approximately 10 hours. As the job progressed and concrete-pouring operations were begun near the portal entrance, the



CROSS SECTION: As shown in this cross section, the excavation in the tunnel between the pay lines was 33 ft. 6 in. wide by 27 ft. 7 in. high. The concrete lining of the walls will be 18 in. thick and 24 in. at the arch.

TOP HEADING: When unstable slate and shale formations were encountered in the tunnel, a top heading was driven until solid rock was reached. Steel sets were placed at 2-ft. centers and gunited.

mucking time slowed down because of the hampering effect on the haulage trucks. It was then decided to drill, load, and fire during the first shift and muck and set steel during the night when concrete work was suspended. A larger, 15-ft., round proved satisfactory for this cycle. Compressed air was supplied through an 8-in. spiraweld line to the heading from four Ingersoll-Rand motor compressors and one 600-c.f.m. Gyro-Flo compressor with a total output of 2,760 c.f.m. A 48-in. steel pipe, carried along the left wall, provided ventilating air to the face from blowers located near the portal.

The type of round used was predicated by the nature of the rock encountered. The round shown is representative of the 15-ft. round.

Using 1¾-in. Carset bits, reground with a bench grinder on the job, drill crews averaged over 500 ft. per bit in the Clinton formation. In the harder Tuscarora formation, this dropped as low as 20 to 30 ft. per bit.

On an average, 100 to 110 holes were drilled in a 10-ft. round, with the cut holes 12 to 13 ft. deep. In the 15-ft. rounds, the average number of drill holes was 110 to 120, with cut holes 18 ft. deep. The explosives-loading factor varied from 2.5 to 3.0 lb. of dynamite per solid cubic yard of rock, determined by the nature of the rock encountered, the length of the round, and the number of holes.

Twelve to 14 Ingersoll-Rand JR-38 jack drills were used to drill the 10-ft. round. When the longer round was adopted, two Ingersoll-Rand DB-35 drifters were mounted with a collar and bar on the center deck to drill the longer cut holes. Because of the increased depth of the round, the cut holes were "double-barreled."

In both rounds, Hercules Gelatin Extra 60% in 1⅛ by 8-in. cartridges was used in the cut and the lifter holes with either Gelatin Extra 40% or Gelamite® 1-X in the remaining holes. The cut holes were primed with Hercules® Short-Period No. 2 and No. 7 Delay Caps and with Hercules® NoVent® Delay Electric Blasting Caps, from the first delay up to and including the tenth delay in a near-concentric pattern out to the rib holes. The caps were connected in parallel using No. 16 bare copper bus wire and fired from a 440-volt blasting switch located 1,500 ft. from the heading.

A trench measuring approximately 5 ft. wide by 5 ft. deep is being blasted along the floor to accommodate a 48-in. drainage pipe. Holes were drilled with two DB-35 drifters mounted side by side on a rubber-wheeled wagon. Three holes are drilled across the width of the ditch every 3 ft. and each hole loaded with four cartridges of Hercules Gelatin Extra 40%. Small sections are blasted at one time and a hemp blasting mat is used as an added safety precaution.

Concrete Lining

A 480-cu. yd.-capacity batch plant is

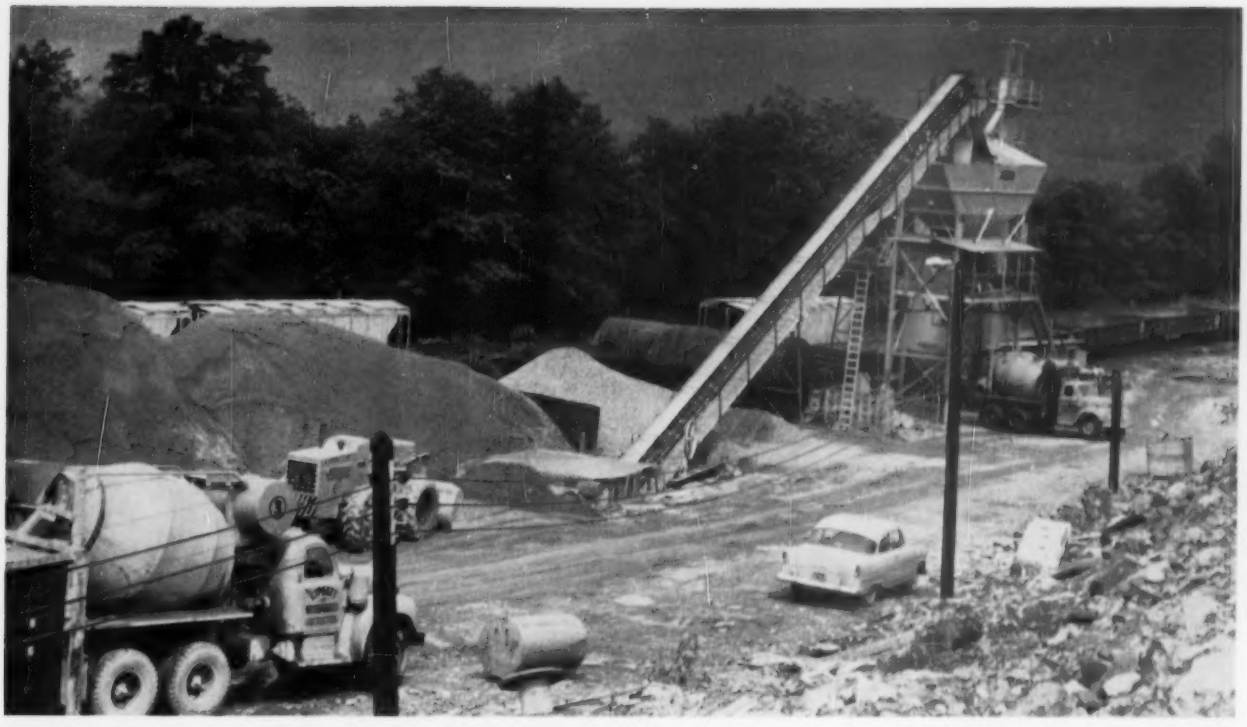
REINFORCING OPERATIONS: Because of stress on steel sets near the south portal section of the tunnel, concrete was poured up to the face. At right, the crew is tying reinforcing rods prior to pouring the concrete side walls.

located to the north of the north portal, and a fleet of transit mix trucks transports the concrete to the tunnel. Eight sets of collapsible Blaw-Knox forms on wide-gauge rolls are being used. A Pumcrete machine pumps the concrete to the forms. Before pouring the concrete lining, corrugated steel sheets are welded to the back of the steel sets and the void between the steel sheets and rib filled with crushed slag. The minimum thickness of the concrete lining is 18 in. on the walls and 24 in. on the arch. The suspended ceiling slab is 6 in., and the overhead passageway will provide a means for ventilating air to the tunnel. The ventilation buildings at each portal are being constructed by Lipsett, Inc., under a separate contract.

As seen by motorists, the tunnel will be 15 ft. 4 in. high and 28 ft. 10 in. in width with small raised catwalks on both sides. The roof and sides will be finished in tile.

The bore of the tunnel was completed on July 3, 1956, and the concrete lining is well under way. The

THE NORTH PORTAL: Most of the driving of the tunnel was done from the north portal to take advantage of a 2.5 per cent grade. The cribbing above the portal was installed to minimize the danger of possible slides.



THE BATCH PLANT: A short distance from the north portal of the Lehigh Tunnel the contractor erected a 480-cu. yd. batch plant and aggregate storage bins. Concrete from this plant was hauled in transmix trucks to the tunnel.

project is scheduled for completion in December, 1956.

Personnel

Formerly known as the T. J. Evans Tunnel, the name of the structure was changed to the Lehigh Tunnel in September, 1956. The present Pennsylvania Turnpike Commission includes G. Franklin McSorley, chairman; James F. Torrance, secretary and treasurer; David E. Watson; and Joseph J. Lawler, secretary of highways, an ex-officio member. The project is supervised by Harry Lundy, senior division construction engineer, in charge of the Northeastern Extension Field Office at Lehighton, Pennsylvania. Alden E. Cornell is inspector on the tunnel project.

Harold Wambacher is resident engineer and Evar J. Forslund, the assistant resident engineer, for Parsons, Brinckerhoff, Hall, and MacDonald, designers of the tunnel.

For the Lipsett organization, Joseph L. Thomas is general superintendent, with Philip Miller the consulting engineer; Michael Carey, project engineer; and Morris Fishkin, general administrator. At the north portal, James Sullivan is superintendent; Otto Bender, Otis Birdsey, and George Rongyos are walking bosses. Allen Burns is the superintendent at the south portal, with William Daggs and James Townsend as walking bosses.

SUPERVISORY PERSONNEL: Lipsett's supervisory force includes, left to right, James Sullivan, north portal superintendent; Michael Carey, project engineer; and Joseph L. Thomas, general superintendent.

MINING MISSOURI LIMESTONE

Switching operations from open-face quarry methods to underground mining increased the production of a variety of products at the Jos. J. Griesemer Quarry

L. H. HOUCK*

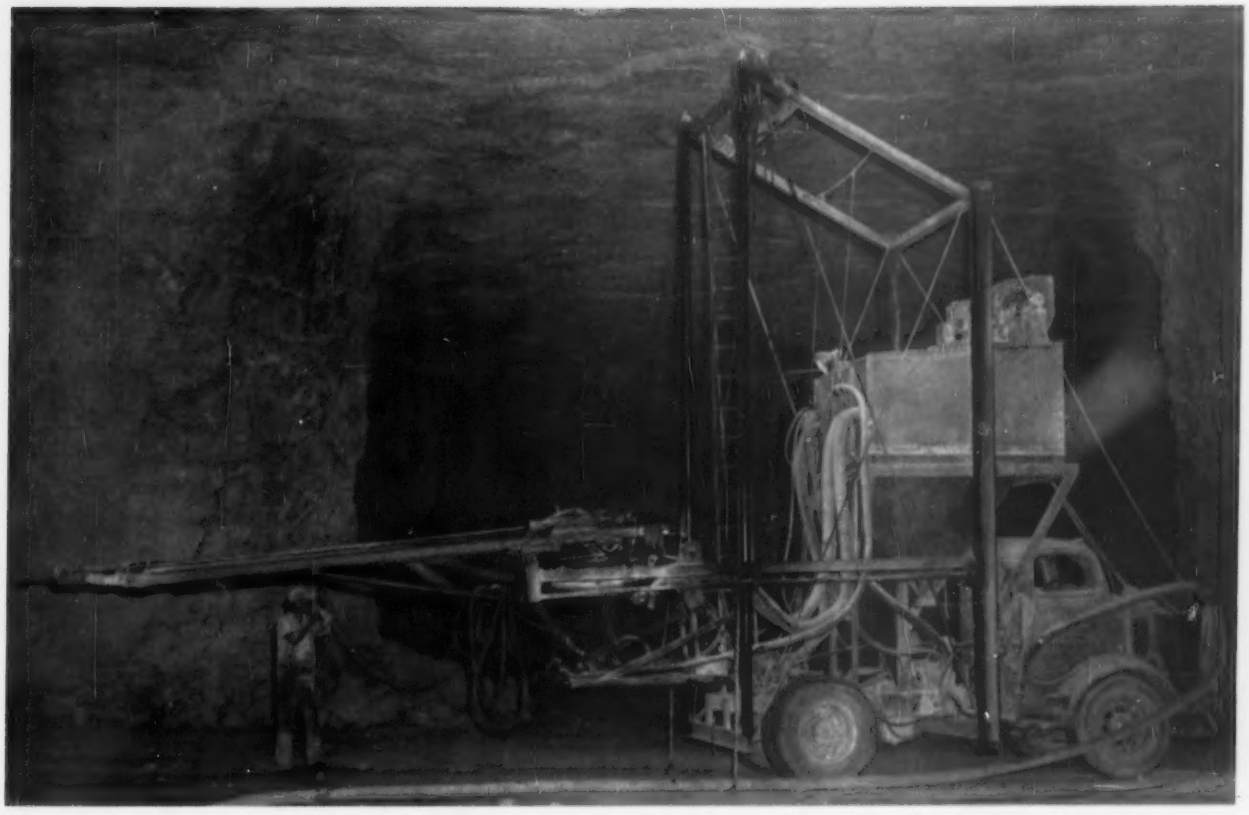
THE Government's multibillion dollar program of highway construction over the next 13 years and expanded programs of state highway departments forecast a huge increase in the demand for crushed and prepared sizes of commercial stone, particularly limestone.

In Missouri, the State Highway Department has several million dollars' worth of construction under way, with much more in the planning stage. One of the important producers of commercial limestone in Missouri is the Jos. J. Griesemer Quarry. This organization, operating on a 40-acre site about a mile east of Springfield, has supplied, and will continue to supply, millions of tons of crushed and prepared limestone for use on highway and allied construction projects.

Jos. J. Griesemer opened his quarry

* 400 Linden Drive
Jefferson City, Missouri

THE MINE LOCATION: Here are two of the four entrances to the Griesemer limestone mine. The water-filled pit in foreground was formerly kept dry when operations were carried on as an open-face quarry. Roadway at right connects the mine with the crushing plant in the background.



THE JUMBO: The jumbo, designed and built in the Griesemer shops, is mounted on a truck. The drill platform is raised and lowered in a vertical track by cables and an air motor located on the base.

in 1947. The location is a stone's throw from U. S. 66, often called the "Main Street of America." The location of the quarry provides ideal trucking facilities as well as railroad service for shipments over the St. Louis & San Francisco Railway.

Prior to entering the commercial stone business, Mr. Griesemer was engaged in the construction business, where he acquired first-hand experience with the problems of obtaining suitable stone for aggregates in sufficient quantities. His experiences prompted his entrance into the crushed stone business.

Geology

The rock formation at the Griesemer quarry is in the broad division of geology known as the Ozark Highlands, one of four physiographic geological provinces in Missouri. The terrain is a rolling structural plain that covers most of the state south of the Missouri River. It is classified as a structural plain because of the easy westerly slope of its surface, which practically coincides with the dip of the underlying Burlington limestone.

Burlington limestone is a high-purity stone found in sufficient quantities in Missouri to make the state one of the large limestone producers. In the general area of the Griesemer quarry, Burlington limestone lies just beneath a normally shallow earth burden. Northeasterly, in the vicinity of the Mississippi River, near St. Louis, a little over a hundred miles away, the Burlington formation lies deep under the St. Louis limestone.

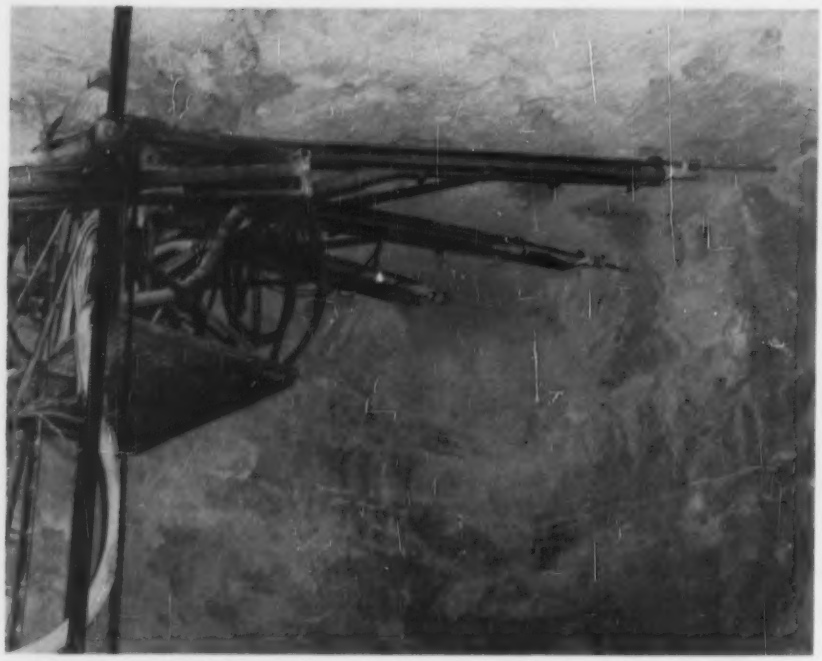
Much of the Burlington limestone in Missouri is thought to have been formed by the precipitation of calcium carbonate from sea water through evaporation in confined estuaries. The consolidation of this ooze shows little trace of organic origin so commonly found in most limestones, representing the calcareous remains of corals, Foraminifera, and mollusks.

The geological theory is that the Burlington limestone was deposited by the arrival of warm seas that opened the long Paleozoic era, some 500 million years ago. Some of the waters came from the Gulf of Mexico and others from the Arctic. They advanced and receded again and again, bringing waters filled with life except in locations such as the Griesemer site, where, apparently, the deposit has been produced entirely by sedimentation.

Many producers of commercial limestone in Missouri are plagued with high admixtures of chert, dolomite, clay seams, and numerous faults, which add to the cost of producing acceptable materials in large quantities. Preliminary tests of the limestone beds in the Griesemer quarry showed 98 per cent calcium carbonate, with only 2 per cent chert.

In the Early Days

In the early days, the Griesemer operations were carried on as an open-face quarry. Stripping the overburden was begun in September, 1946, using a ¾-cu. yd. Lorain power shovel. Six



DRILLING BLAST HOLES: Holes for blasting in a working face are drilled 12 to 14 ft. deep with three Ingersoll-Rand drifter drills mounted on a platform. Air is supplied by a Chicago-Pneumatic rotary compressor.

months later the construction of a crushing and screening plant was completed, and crushed and sized stone was produced at the rate of 100 tons an hour. This production schedule was maintained during the next eight years. In 1955, operating methods were changed from open-face quarrying to underground mining.

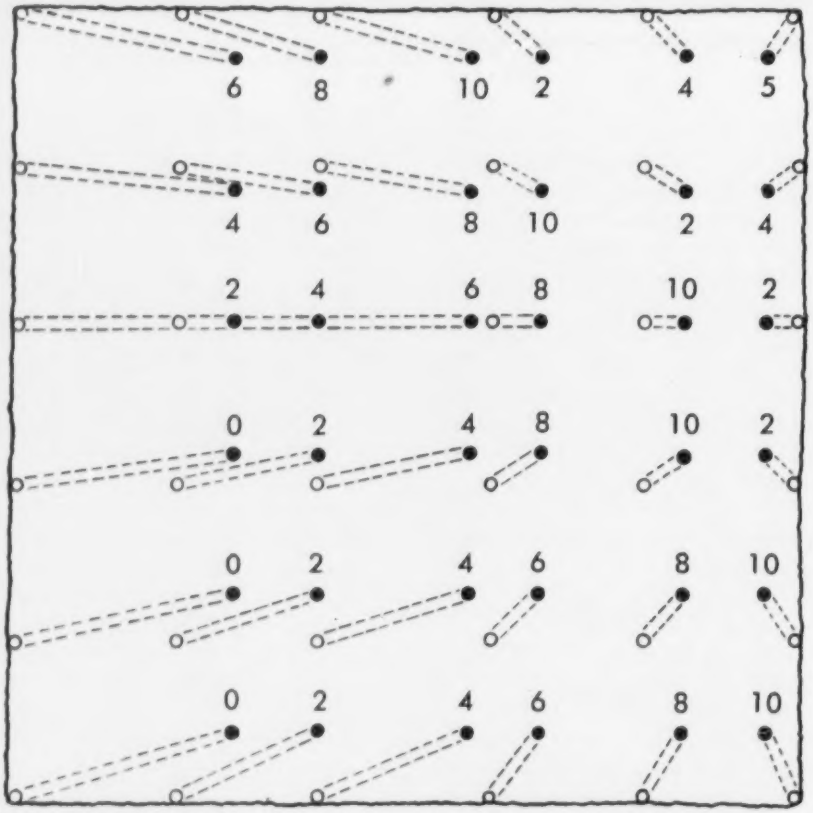
Several reasons prompted this change: the overburden had reached an approximate depth of 20 ft., which increased stripping costs by conventional methods; the formerly smooth, flat top of the Burlington beds had changed to a pock-marked surface spotted with pinnacles ranging from a few feet to 20 ft. high, involving slow and expensive hand labor; and, finally, the proximity of the operation to busy U. S. 66 tended to increase the public liability potential.

Because of these factors, it was decided to go underground by tunneling in a southerly direction into the high rock walls of the southern rim of the old quarry. In order to supply the heavy demands for its high-quality products, the Griesemer organization operated both the quarry and the mine. However, during the past year all production has come from the underground workings. The Burlington formation being mined is a rather soft limestone, approximately 50 ft. thick, extending over the entire 40-acre site. The room-and-pillar method of mining is used.

Tunneling Methods

In going underground, Griesemer crews started driving four tunnels, or drifts, 50 ft. wide and 25 ft. high. This method provided for a minimum ledge of solid rock above the tunnels measuring 25 ft. thick. As the tunnels were advanced, 30 by 30-ft. pillars were left, with cuts made to the right and left of each pillar and connected in the conventional room-and-pillar system of mining.

This procedure provided a working face 50 ft. wide and 25 ft. high. When a tunnel was advanced 80 ft., the cut on each side for the pillar provided two more similar-sized working faces. Since all material was "pay dirt," it was possible at these points to drill



DRILL ROUND PATTERN: This is the pattern for drilling a round of holes in one-half of a working face (the right side) in the Griesemer mine. When both sides of the face are drilled, the round comprises 72 holes 12 to 14 ft. deep. The numbers indicate the delay periods of the electric blasting cap primers.

three faces simultaneously. Usually, only two of the faces were blasted at one time.

In the first year of underground mining operations, four tunnels in the 500-ft.-long wall of the old quarry face were advanced approximately 500 ft., and connected laterally at 30-ft. intervals. Routine procedure is to advance a heading 80 ft., then turn and cut a pillar. The mine itself is high, wide, and dry, with excellent natural ventilation.

A Unique Jumbo

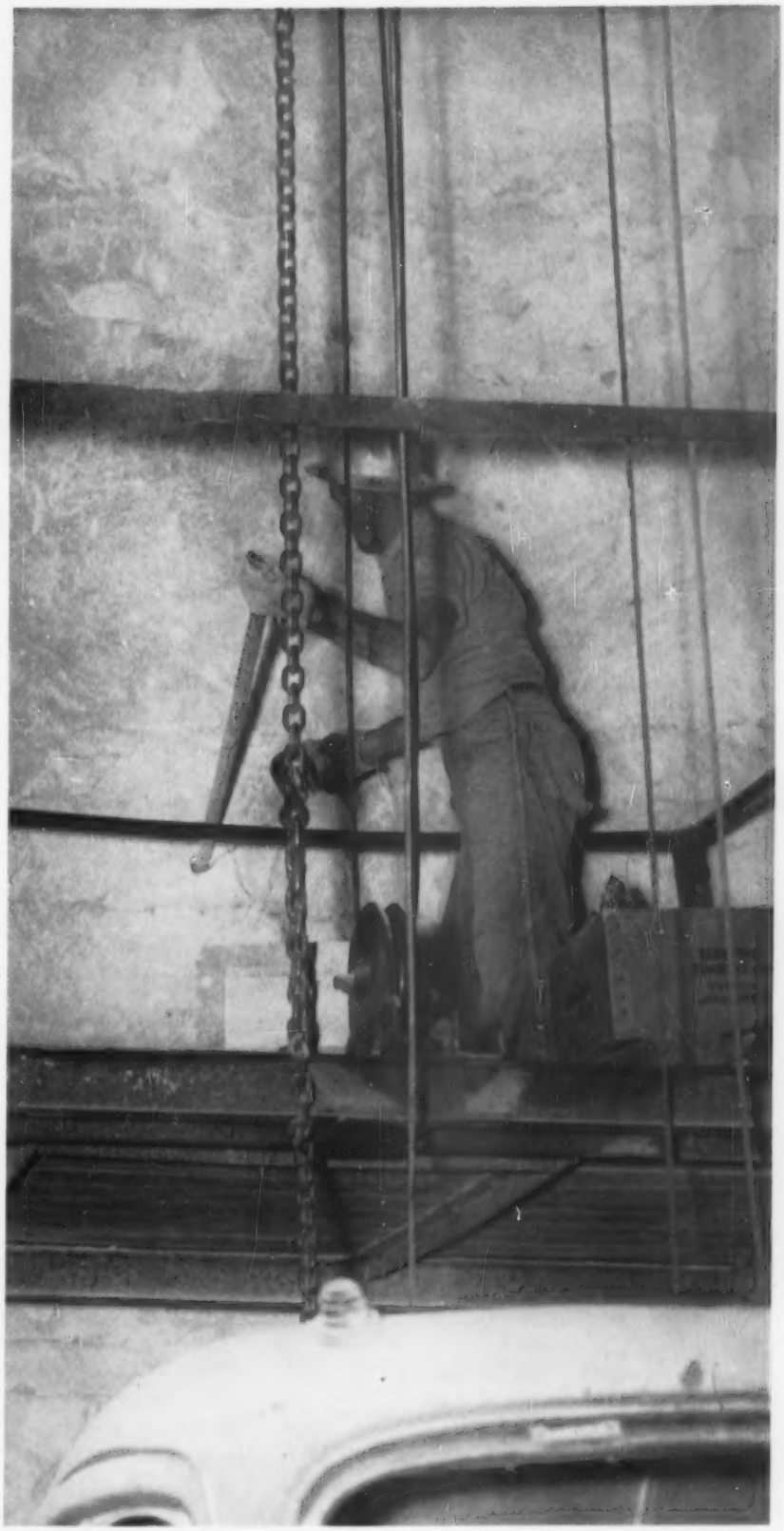
Switching from an open-face quarry to an underground mine required many changes in methods and equipment, notably the drilling of horizontal blast holes into a heading 25 ft. high. Several time-tested methods were available, such as tripod mounting for drills, standard and pneumatic columns, air legs, and others; but all required considerable setup time. Finally, it was decided to use a jumbo.

The first unit introduced was a commercially available jumbo that mounted a pair of drifters on a steel boom. It was abandoned because it couldn't carry sufficient drills or provide adequate means for maintaining correct drill angles, which were needed for maximum rock breakage.

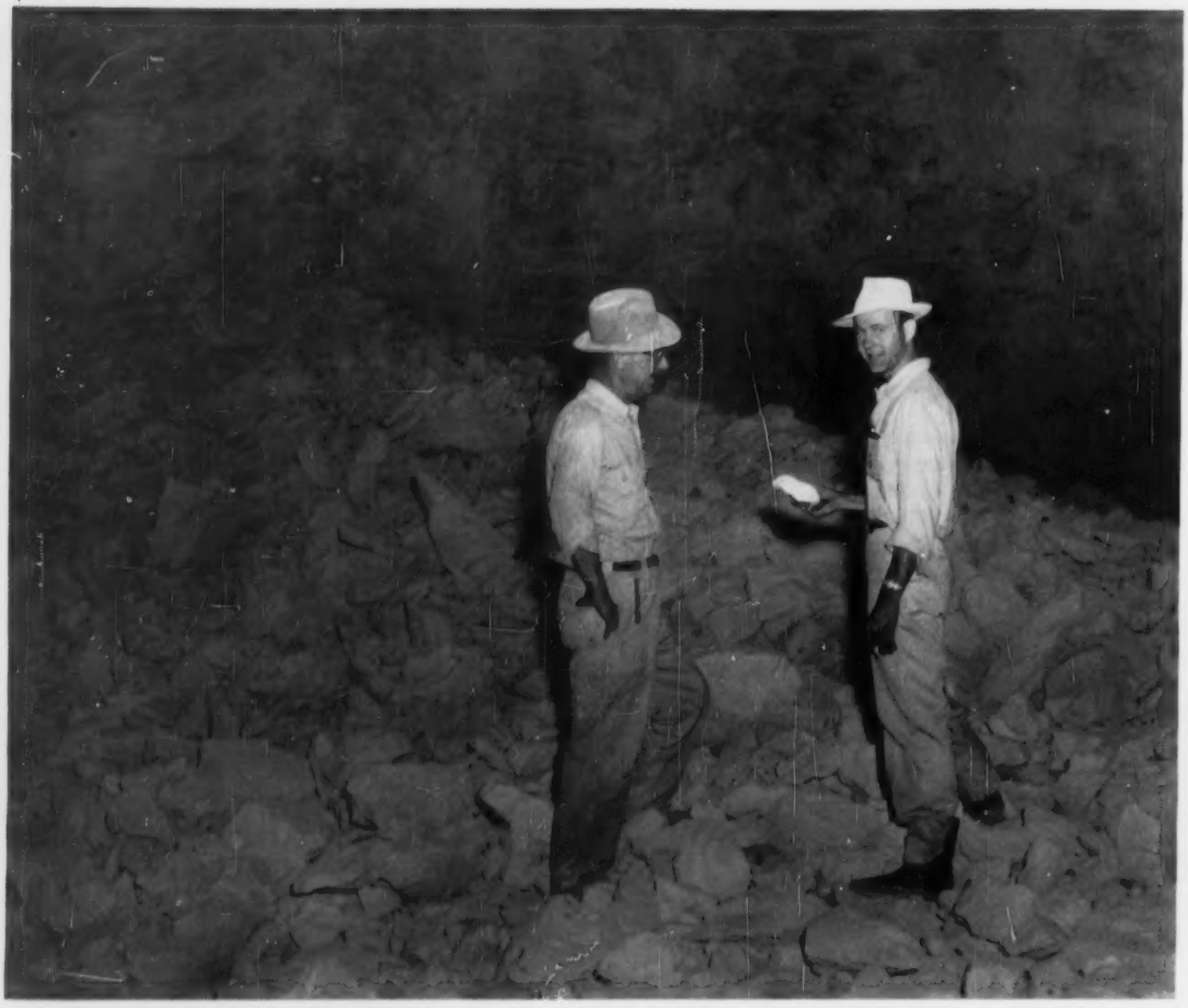
This failure led to the design and construction of a rig especially for this mining job. In due course, the new jumbo was built in the company's shops on the property.

The Griesemer jumbo mounts three Ingersoll-Rand DB-35 drifter drills on a platform in a vertical frame mounted on a Mack truck with pneumatic tires. Most jumbos are either mounted on crawler tracks or on steel rails. The drill platform is raised and lowered vertically in a fixed track, and is controlled by cable and drum. The drum is powered with a Gardner-Denver air hoist, and the platform can be maneuvered from roof to floor by air throttle.

Each drifter drill is equipped with a special dust collector with a retractable steel tube. The tubes are connected to a suction blower which is operated by a 5-hp., 220-volt, three-phase electric motor mounted on the lower platform, or base. The exhaust of the



LOADING EXPLOSIVES CHARGES: Working from a vertically adjustable platform, a two-man crew loads 600 to 700 lb. of Hercomite into the 72 drill holes in a face. The loading ratio is 1.3 lb. of dynamite to 1 cu. yd. of limestone in place.



EXCELLENT FRAGMENTATION: The excellent fragmentation from blasts is evident in this picture. John Griesemer, plant superintendent, right, and Virgil Lawrence, mine superintendent, are obviously happy about the good breakage results.

blower deposits the collected dust in a large closed bin on the machine, which is emptied when necessary.

A working face is drilled with detachable 2-in. Carset jackbits on 16-ft. lengths of 1¾-in.-round steel. The holes are drilled to average depths of 12 to 14 ft.

Air for the drills is supplied by a Chicago Pneumatic rotary compressor, located outside the mine near the entrance to one of the tunnels. It has a capacity of 900 c.f.m., and is powered with a GMC 6-110 two-cycle diesel engine, which, being automatically controlled, provides a constant supply of air at 90 to 110 p.s.i.

Inside the tunnel, air is piped from a compressor to an air receiver located in one of the first laterals. Four-inch steel pipe is used for the air-supply line, and the air receiver is equipped with automatic water-trap drains. Air mains are laid on the floor in a lateral loop across the approximately 500-ft. width to be within easy reach of the hose that supplies the drills on the jumbo.

Drilling Holes for Blasting

The pattern for drilling a round of blast holes in the 50 by 25-ft. face comprises 72 holes spaced on approximately 3½-ft. centers. The holes are 2 in. in diameter and 12 to 14 ft. deep. Only two moves are required to spot and set up the jumbo and drill out a complete round. The rig is backed along the right side of the heading, spotted approximately 1 ft. from the rib, and positioned with the drill bits just touching the face. For rigidity, jacks are placed just behind the rear wheels and pneumatic rams drive two pins to the roof. The top six holes, across one-half the face, are drilled first, two holes per drill. Then the platform is lowered to drill the next row of holes, until the right face of the round is drilled out.

This same procedure is followed on the second setup on the left side of the face.

Definite angles are prescribed for the various drill positions. They are pegged into the template on the drills so that each drilling sequence for a

complete face is always the same.

This drill pattern leaves an area in the center of the face 14 ft. wide which is undrilled. However, this is broken in a blast because of the angle of the center holes. Strict adherence to this drilling routine has produced fragmentation of limestone that fits the size of the primary crusher. Also, it has reduced secondary breakage to a minimum.

Blasting Procedure

The dry nature of the limestone formation is ideal for pulling the desired yardage by blasting with Hercomite® 3 and Hercomite 4 dynamites. The 72 holes in a round are loaded with 600 to 700 lb. of these dynamites, packed in 1¾ by 16-in. cartridges.

A two-man crew loads the explosives into the holes from a vertically adjustable platform mounted on a pneumatic-tired truck. The dynamite charges in the holes are primed with 2 to 5 periods of delay electric blasting caps and 0 to 10 periods of short-period delay electric blasting caps, according to the requirements of the blasting pattern. Each charge is stemmed to the collar of each hole with lime sand in paper bags. The cap leg wires are connected in a two-series hookup, and blasts are fired with a Hercules 50-cap blasting machine.

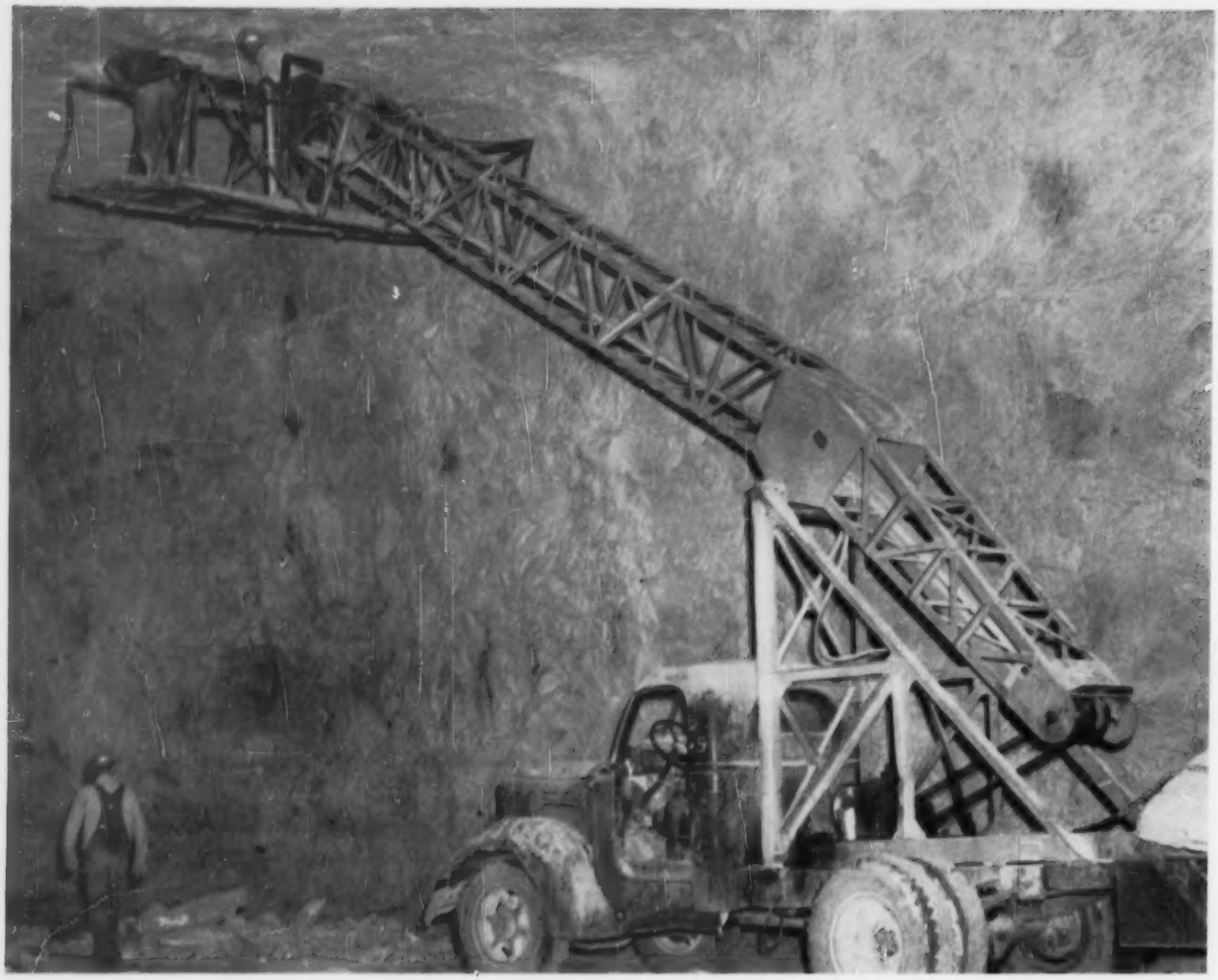
Blasting is done at the end of the day shift, shortly after 5 p.m. Results average 1 cu. yd. of limestone for each 1.3 lb. of dynamite loaded, or 1.8 tons of broken stone per 1 lb. of dynamite. The tunnel advance from each blast averages 10 to 12 ft.

Loading the Limestone

Loading of the blasted limestone at a heading is done with an L-50 Lorain power shovel equipped with a D-318 Caterpillar diesel engine. The dipper on the shovel was especially designed by Mr. Griesemer and manufactured by Esco. It is wider and shallower than standard makes, and, being tailored to the rock it is to handle, does an excellent scooping job. It loads into a fleet of four Euclid end-dump, diesel-powered trucks. Two of the Eucs are UD models with 10-ton struck capacity, powered with 4-71 GMC diesels; the other two are FD's, 15-ton capacity, with 6-71 GMC diesel engines.

The haul to the mill is uphill, about 1,500 yd. long. While the grade is considerable, the road is kept smooth.

LOADING BLASTED LIMESTONE: Loading at a heading is done with a Lorain shovel which dumps the limestone into Euclid trucks. The shovel dipper was especially designed by Jos. J. Griesemer.



ROOF SCALING: Loose slabs of limestone are pried from the roof of the mine by a two-man crew. They work from a counter-balanced rig with an adjustable boom.

Usually, three Euclids can keep the plant running at capacity.

Crushing and Screening

At the plant, the trucks dump into a 30-in. by 14-ft. apron feeder and scalping grizzly, which feeds into a 30 by 30-in. Cedar Rapids double-impeller impact breaker. This primary breaker is powered by a D-17000 Caterpillar diesel engine.

The secondary crusher was especially designed by Mr. Griesemer. Basically, it consists of two conventional secondaries in tandem, providing an unusually flexible flow of different-sized materials at the same time. The conveyor system can put all of the rock over one secondary, or it can split the rock between the two. This permits the loading of two different sizes of stone into two railway cars at the same time. Or, both plants can load to trucks, or one to trucks and the other to storage hoppers. In short, almost any desirable combination is possible.

The plant nomenclature characterizes one secondary as the "North" and the other as the "South." The North has a 24 by 40-in. Universal roll crusher, powered with a D-17000 Caterpillar diesel and a two-deck 5 by 14-ft. Simplicity screen powered with a D-315 Caterpillar. The South secondary uses an 18 by 30-in. Cedar Rapids roll crusher which feeds into a 4 by 12-ft., three-deck Simplicity screen, which uses a D-311 Caterpillar diesel for power.

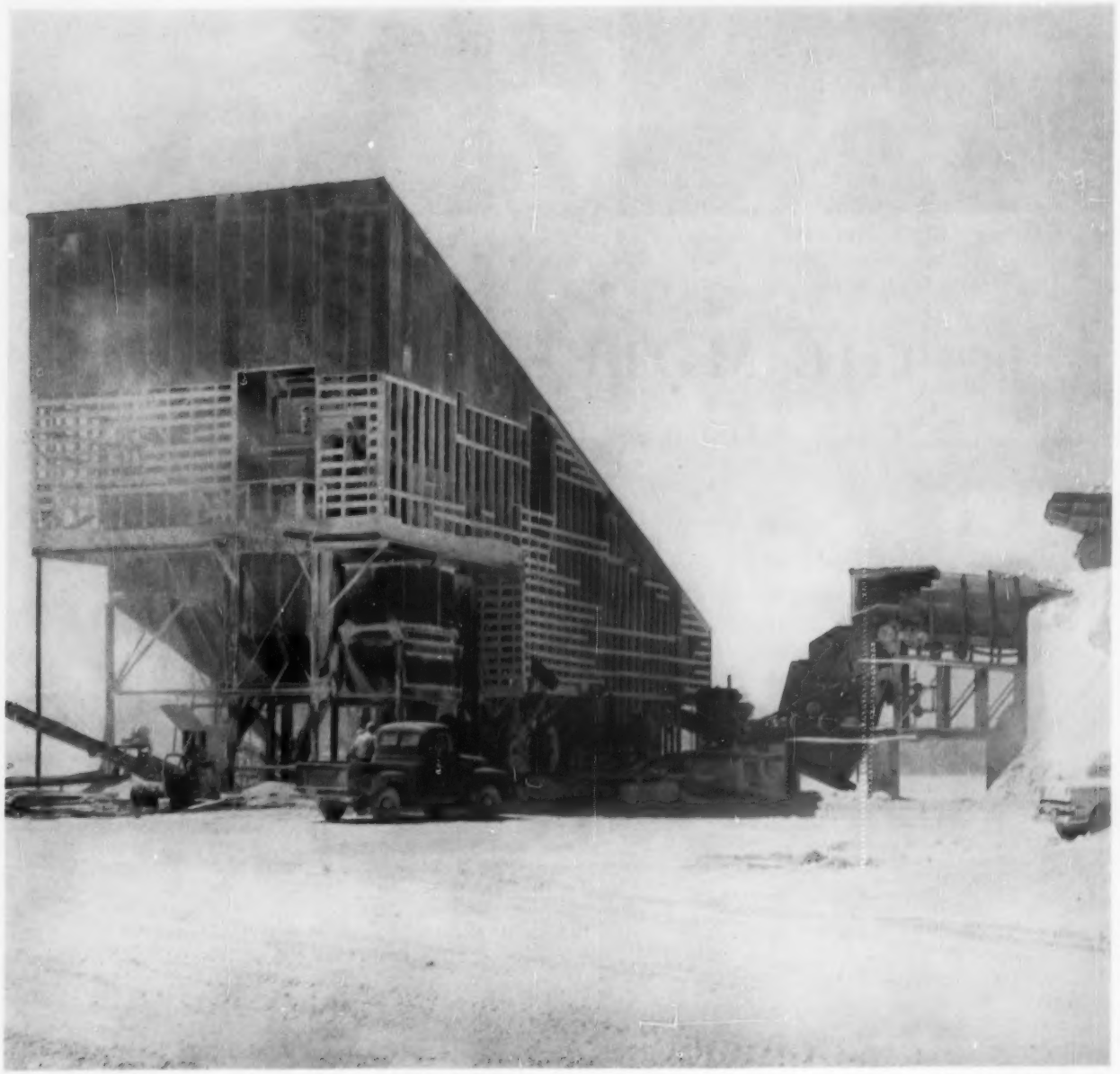
Much of the 200-ton-per-hour output of this efficient plant goes directly into railroad cars. Many times, upwards of 20 such cars are needed at one time for loading. Local trucks are loaded by gravity from bins. Stockpiled material is loaded into trucks by a Hough Payloader, Model HM, powered with a Hercules gasoline engine. When necessary, this unit is used to load railroad cars from stockpiles.

The many uses for the limestone products of the Jos. J. Griesemer Quarry include sub-base materials for concrete and asphalt highways, paving rock, stone for bridge piers, masonry construction, and agriculture. Besides these conventional uses, the Griesemer organization produces filter stone for sewage-disposal plants. An acceptable grade of limestone for this last purpose is found only in a limited number

of mines and quarries. In Missouri, the product must pass the 20-cycle sodium sulphate test of the Department of Health. The Griesemer products consistently meet the requirements as to quality and accurate sizing.

Jos. J. Griesemer is the owner and operator of the company which bears his name. His son, John, a graduate engineer recently returned from U. S. Army service in the Far East, is superintendent of the plant. Virgil Lawrence, superintendent of mining operations, rounds out the key supervisory personnel.

KEY PERSONNEL: Operations at the limestone mine and plant are directed by, left to right, Jos. J. Griesemer, owner; his son, John Griesemer, plant superintendent; and Virgil Lawrence, mine superintendent.



CRUSHING PLANT: This plant, averaging a production of 200 tons an hour, supplies crushed and sized limestone for a wide variety of purposes in the construction and agriculture fields and to sewage-disposal plants.

GUY F. ATKINSON

LOUIS R. PERINI

THE MOLES AWARDS

Guy F. Atkinson and Louis R. Perini to receive bronze plaques and citations for outstanding contributions to construction progress

THE Awards committee of The Moles, an association of prominent executives in the heavy-construction industry, recently announced that Guy F. Atkinson, board chairman of Guy F. Atkinson Company, San Francisco, and Louis R. Perini, president of B. Perini & Sons, Inc., Framingham, Massachusetts, will receive The Moles awards for 1957. The awards, bronze plaques and citations, are made for outstanding contributions to construction progress. They will be presented at the seventeenth annual dinner-meeting of the association on Thursday, February 7, 1957, in the Waldorf-Astoria Hotel, New York City. More than 1,000 contractors, engineers, and industrial leaders will attend the ceremonies.

The Moles awards are made annually to one member and one nonmember of the association. In announcing the winners for 1957, Harry T. Immerman, chairman of the committee, said that Mr. Atkinson and Mr. Perini were chosen "for outstanding achievement." These awards are considered to be the highest recognition that can be accorded individuals for service to the construction industry in America.

Former winners include former President Herbert Hoover, Admiral Ben Moreell, and the late General Brehon B. Somervell.

Guy F. Atkinson

Guy F. Atkinson is the board chairman of a company that has completed more than 100 major heavy-construction contracts in this country and overseas. The list includes such mammoth jobs as Grand Coulee Dam, McNary Dam and Powerhouse, Treasure Island for the San Francisco World's Fair, and the Hanford, Washington, atomic energy plants. He is a past president of the National Associated General Contractors.

Louis R. Perini

Louis R. Perini directs the affairs of a heavy-construction organization that has been identified with many of the largest dam and tunnel projects in the East during the past 20 years. He is also the president of the Milwaukee Braves baseball team, having purchased the club with his brothers Joseph and Charles in 1945, when it was a Boston franchise. He is a past president of the New England Road Builders Association.

MINERS HONORED FOR SAFETY ACHIEVEMENTS

Company officials pay tribute to employes at ceremonies highlighted by awards of Sentinels of Safety trophies and flags

RESULTS of the National Safety Competition of 1955 were published in the July-August issue of THE EXPLOSIVES ENGINEER. The 529 mines and quarries in the United States that participated in the competition last year attained the best overall safety record since the start of the contest in 1925.

Each year, awards are made at public ceremonies held at the properties of most of the winning operations. Brief descriptions are given here of four award ceremonies held this year in various parts of the country.

Alabama By-Products Corporation

Employes of Alabama By-Products Corporation's Labuco Mine, Flat

THE LABUCO BARBECUE: Labuco miners, their families, and invited guests enjoyed a barbecue luncheon in a grove, with officials of Alabama By-Products Corporation as hosts.

THE TROPHY AWARD: John M. Martin, general manager of the Explosives Department, Hercules Powder Company, at right, officially awards the Sentinels of Safety trophy to G. Dempsey Sparks, superintendent of Labuco mine.

Creek, Walker County, Alabama, and their families listened intently as impressive tributes were paid to the miners for their accident-free safety record in 1955. Management representatives and workmen, Federal and State officials, and others praised in glowing terms the Labuco miners for winning top honors for the second successive year in the National Safety Competition, bituminous-coal mine group.

A barbecue luncheon was held in a grove near the mine property on August 10, as the opening feature of ceremonies arranged by the corporation.

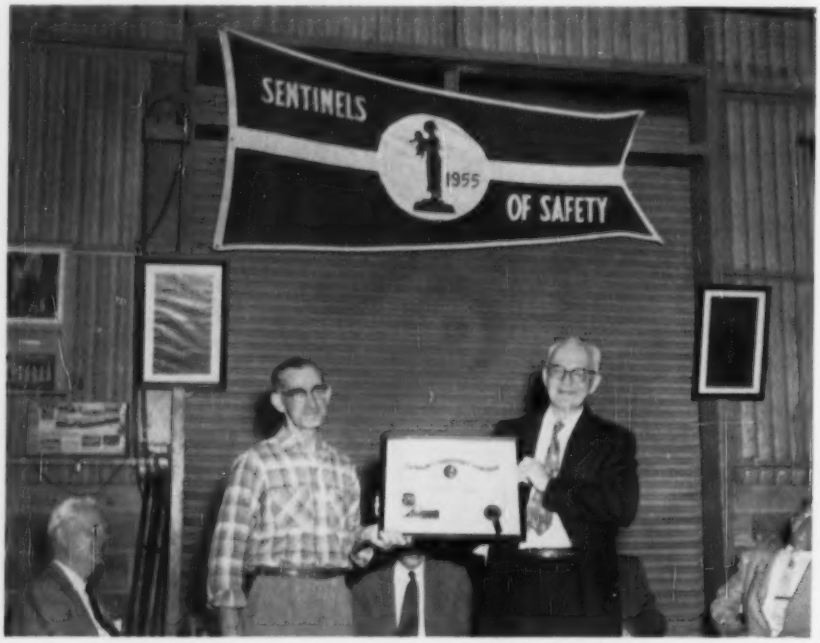
Following the luncheon, Henry J. Hager, vice president in charge of Alabama By-Products' mining activities, extended congratulations from everyone in the organization to the Labuco miners on their winning the Sentinels of Safety trophy for two years in a row.

F. G. Koenig, Jr., executive vice president of the corporation, lauded the miners and their supervisors for the wholehearted cooperation of workmen and management in the making of outstanding safety records.

At the conclusion of Mr. Koenig's address, congratulations were extended to the Labuco miners by G. C. Dyar, general superintendent of mines; William Mitch, president of District 20, United Mine Workers of America; George Huddleston, Jr., U. S. Congressman from Alabama's 9th district; and H. T. Williams, chief of the Safety and Inspection Division of Alabama's Department of Industrial Relations.

John M. Martin, general manager of the Explosives Department, Hercules Powder Company, representing THE EXPLOSIVES ENGINEER, presented the Sentinels of Safety trophy to Labuco Mine. In congratulating the winners, Mr. Martin said, "I take off my hat to you men and management, the union, the U. S. Bureau of Mines, the Federal and State inspectors, all who have helped to make possible the winning of this trophy."

Thomas E. Miller, manager of the Extension Division of Hercules, presented the Sentinels of Safety flag. "This green-and-white flag, designed especially for the winners in the National Safety Competition, should fly proudly over your property," Mr. Miller said. "And every day, when you



THE HOLMES AWARD: A. E. Morrow, right, U. S. Bureau of Mines, awards a Joseph A. Holmes certificate to George Kellerman, Bell Mine employe. Joseph I. Horty, seated, editor of The Explosives Engineer, awarded the Sentinels of Safety trophy and flag to the mine.

AT ERIE MINE: Speakers and distinguished guests on the platform at the presentation ceremonies at Aurora, Minnesota, honoring the Erie Commercial Mine. Tom C. Thielman, general superintendent at Erie, at the lectern, was master of ceremonies.

come to work, you will see it at the top of the flagstaff, and it will remind you to continue to work safely and make more records."

G. Dempsey Sparks, superintendent of Labuco Mine, accepted the trophy and flag on behalf of his mine associates.

James Westfield, assistant director, Health and Safety Division, U. S. Bureau of Mines, presented the Certificates of Accomplishment in Safety to the Labuco Mine employes. "You people have something I would like to carry with me to every mine and quarry in the United States," Mr. Westfield said. "Statistics don't tell us what it is that you have. People here get together and work together to one end, perfect examples of team spirit. That is what you Labuco miners have that keeps you working safely."

Lawton Wilson, president of Local No. 5831, U.M.W.A., representing the employes, accepted the certificates from Mr. Westfield.

High praise for the cooperative spirit of the Labuco employes came from Milton McCall, district supervisor of Health and Safety, U. S. Bureau of Mines. "The Alabama By-Products Corporation has given us wonderful cooperation," Mr. McCall said. "We in the Bureau gain some reflected glory when one of its mines wins this award."

At the conclusion of his remarks, Mr. McCall presented the Joseph A. Holmes Certificate of Honor to the mine for having no fatalities during 3,137,935 man-hours of work underground.

The Joseph A. Holmes Safety Association buttons for men who have worked 20 and 30 years without a lost-time accident were presented to 22 miners by P. H. Word, safety director for the Labuco and Bradford Mines.

Warner Company

On September 12, officials of Warner Company honored the employes of their Bell Mine, Bellefonte, Pennsylvania, for having won first place among 54 contestants in the nonmetallic mines group of the National Safety Competition of 1955. Bell Mine's winning record was 264,075 man-hours of work underground without a lost-time injury.

Fred Warner, general superintendent of the company's Bellefonte Division, was master of ceremonies at the meeting in the plant at Bellefonte.

The bronze Sentinels of Safety trophy and the green-and-white flag were officially presented to the mine and its employes by Joseph I. Horty, editor of THE EXPLOSIVES ENGINEER. Pat Corre, superintendent of Bell Mine, accepted the awards as the representative of the employes.

Certificates of Achievement in Safety were given to each Bell miner by A. E. Morrow, representing the U. S. Bureau of Mines.

George Kellerman and Wilbur Boughman received Joseph A. Holmes Certificates of Honor from Mr. Morrow for accident-free records during many years of work in and around Warner Company's Bell Mine.

Pickands Mather & Company

For the second successive year, Pickands Mather & Company celebrated the awards of two Sentinels of Safety trophies and flags to its mines: Erie Commercial Mine in the open-pit group, and Zenith Mine in the underground metal-mine group. Both mines were winners in the National Safety Competition of 1955.

In 1955, the Erie Mine worked 558,010 hours without a lost-time in-

ACCEPTING THE TROPHY: R. W. Bell, left, assistant superintendent at Erie Mine, accepts the award of the trophy from M. J. Ankeny, director of the U. S. Bureau of Mines.

jury, and the Zenith Mine had a perfect safety record during 529,373 hours of work.

On Saturday afternoon, October 20, approximately 400 employes, their families, and invited guests assembled at the Erie Mine to participate in award ceremonies. Tom C. Thielman, general superintendent of the mine, was master of ceremonies. Following the ceremonies, a buffet supper was served.

The Zenith miners and their families were honored at ceremonies on October 21, in the Community Center Building at Ely. William Langen, principal of the local high school, was the master of ceremonies. The award presentations were preceded by a dinner served to 250 guests.

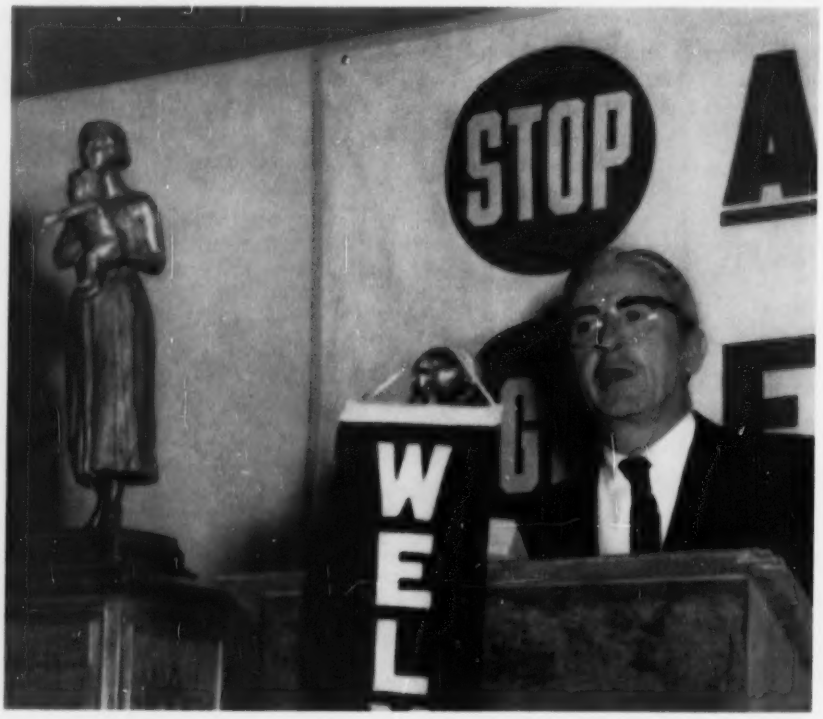
At the Erie Mine ceremonies, Mr. Thielman extended congratulations to the winning miners and a welcome to everyone present. He then introduced William Eckert, director of safety, Pickands Mather & Company. Mr. Eckert commented on the significance of winning a Sentinels of Safety trophy in a contest among the foremost mining operations throughout the nation. He told the employes that the company's management personnel maintains a close watch of the proceedings of the National Safety Competition. "Naturally, when one of our mines establishes a winning record and is awarded a Sentinels of Safety trophy, all of us in the organization are proud and happy," he said.

Following Mr. Eckert's talk, messages of congratulations were extended to the Erie miners by Larry Johnson, operating assistant from the company's Duluth office, and Ben Kangas, mine inspector for St. Louis County, Minnesota.

The Sentinels of Safety trophy was presented to the Erie and Zenith miners at their respective ceremonies by Marling J. Ankeny, director of the United States Bureau of Mines. "To achieve success in accident prevention, safety must be worked at constantly," Mr. Ankeny said. "It is gratifying that the injury-severity rate was significantly lower in 1955, and the injury-frequency rate was at a new record low for the competition series." In conclusion, Mr. Ankeny stated that "the 529 competitors in the National Safety Competition last year represent the cream in accident prevention."

Robert W. Bell, assistant mine superintendent at Erie, accepted the award of the trophy for his mine associates, and Ben S. Richards, superintendent of the Zenith Mine, accepted for the Zenith miners.

Thomas E. Miller, representing THE EXPLOSIVES ENGINEER, presented a Sentinels of Safety flag to each of the



THE FLAG AWARD: In awarding the flag to the Zenith Mine, T. E. Miller, representing The Explosives Engineer, outlined the symbols embodied in the awards of both the Sentinels of Safety trophy and flag.

two winning mines. He outlined the symbolism embodied in the awards of both the Sentinels of Safety trophy and flag. The flag, a green-and-white burgee designed especially for this competition, is given to each winner to be flown over the mine or quarry.

Continuing, Mr. Miller pointed out that the bronze trophy represents a mother holding her baby in her arms, and the baby is reaching out to welcome the father upon his safe return home from the mine. He urged the miners to keep this picture of their wives and children in their minds as they work. "If you will do that, it will help stop you taking chances which could lead to injury or death," he said.

At the Erie Mine ceremony, George Dill, president of Erie Local, United Steel Workers of America, accepted the Sentinels of Safety flag. Art Anderson, president of the Zenith Local, received the flag on behalf of his associates at the Zenith Mine.

Charles Matson, mine captain at Zenith and chairman of its foremen's safety committee, accepted the award of merit for his fellow miners.

Robert C. Baxter, assistant mine superintendent at Zenith, received the National Safety Council's award of honor for the mine.

Samuel A. Gustafson, chief of the Minneapolis field office of the United States Bureau of Mines, presented the Joseph A. Holmes Certificates of Honor to both the Erie and the Zenith Mines.

Arthur Slade, chairman of the Employes' Safety Committee at the Erie Mine, accepted the certificates for the miners, and Matt Banovetz, chairman of the Employes' Safety Committee of the Zenith Mine, accepted them for his group.

Allen D. Look, district engineer, United States Bureau of Mines, presented individual Certificates of Achievement in Safety from the Bureau to the employes of both mines He said special praise was due the winners in the open-pit and metal-mine classifications in 1955 because "last year's competition was the toughest in the 31-year history of the contest."

Following the ceremony at Erie Mine, three Boy Scouts, sons of local miners, raised the Sentinels of Safety flag over the property and sounded the call to the colors.

RAISING THE FLAGS: After the ceremonies, three Boy Scouts, sons of Erie miners, raised Old Glory and the Sentinels of Safety flag to the top of the mine flagpole.

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Designed in the Hercules Research Center after careful study of actual offshore requirements, these new, improved steel containers meet all prospecting requirements included in reflection and refraction shooting.

Hercules representatives welcome the opportunity to discuss with you how Vibronite-B packed in these modern containers can assist in your seismic work.

Technical Data

Vibronite-B is packed in distinctive, light blue containers of heavy-gauge steel to withstand transportation, handling, and storage conditions, and to prevent water and moisture penetration. They have a density greater than salt water, which eliminates all possibility of floating charges. These completely new containers are also equipped with large bails and recessed ends to facilitate loading and unloading in the holds of boats, and to provide convenient handling by shooting crews. Hercules Vibronite-B is now available in five container sizes: 8 inches by 50 pounds; 8 inches by 40 pounds; 5½ inches by 25 pounds; 4½ inches by 16⅔ pounds; and 4½ inches by 10 pounds.

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"Enormously pleased. The 40-R surprised everybody favorably."—Copper mine operator.

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"A good machine. We like the leveling jacks and dust control system."—Machine operator at a Montana mine.

"Best machine I ever ran. We do the work of five cable tool drills."—Machine operator at an open pit copper mine.

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- Hydraulically-powered down pressure on the bit provides maximum controlled penetration.
- Ward Leonard electric control on rotation of the drill pipe permits drilling at the most efficient speed for a given formation.
- Hole can be drilled continuously for 27 ft. 9 in. before an additional drill pipe section has to be added.
- Compressed air is used to remove cuttings and to cool the bit. Fine cuttings are picked up and handled by a Roto-Clone precipitator; heavies pile up adjacent to the drill hole for use as stemming material.
- A remote-controlled, power driven drill pipe rack, eliminates any manual effort on the operator's part when adding or removing drill pipe.

In addition to the 40-R, which drills 6¾- to 9-in. holes, there is the 50-R for drilling 9⅞- to 12¼-in. holes. Write today for detailed specifications and illustrated literature. Learn how one of these drills can cut you in on higher-profit production. 44B56C

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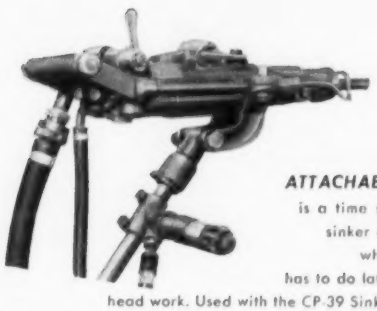
South Milwaukee, Wisconsin

INTEGRAL TYPE — is primarily designed for production drilling. It is used in combination with the CP-32 AW Sinker for general Airleg work. For harder formations and deep-hole drilling it is combined with the CP-59 W Sinker. Provided with push-button releases at both ends of Sinker handle.



ATTACHABLE TYPE — is a time saver for the sinker drill operator who frequently has to do lateral or overhead work. Used with the CP-39 Sinker for soft to medium formations; the CP-32A Sinker for general Airleg work; and the CP-59 Sinker for hard formations or deep-hole drilling. Safety push-button release is in feed throttle handle.

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CP Integral and Attachable Airlegs are designed to get the most out of Tungsten Carbide bits by keeping bit pressure constant even when line pressures or rock formations vary. Because of their exceptional control the pressure-balanced legs take recoil shock in stride... reduces bit slapping and drill breakage. Assures smoother handling of drills. Standard feeds for both types are 36″ and 48″. For more complete Airleg information write direct to *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, New York.*

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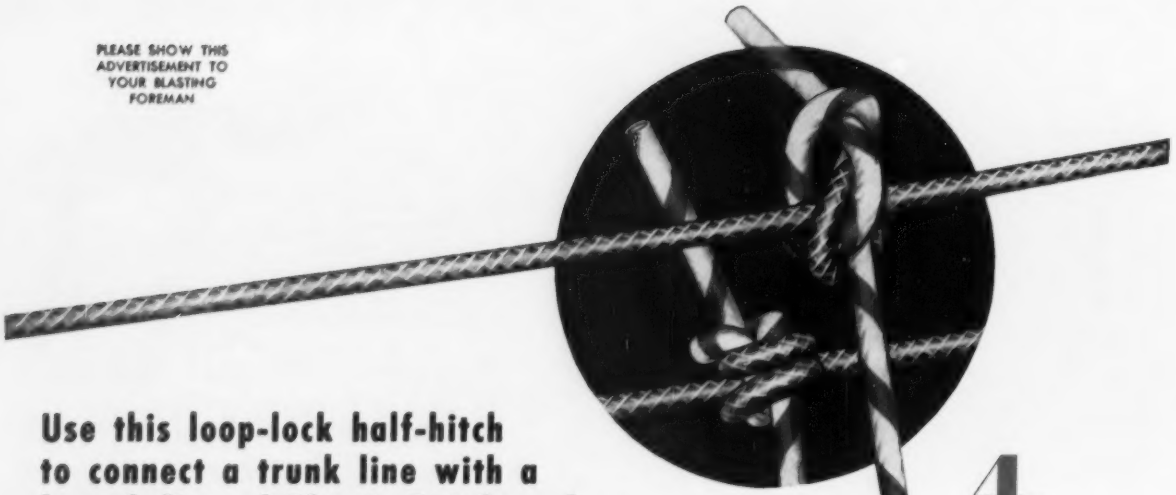

Use this loop-lock half-hitch to connect a trunk line with a branch line of Plastic Reinforced or

PLASTIC WIRE COUNTERED PRIMACORD

This type of Primacord is highly resistant to abrasion and shearing. It is also extremely strong (300 pounds tensile). It is waterproof, and resistant to acids . . . . All of which makes this type the ideal Primacord for use with metal and fibre explosives containers . . . in deep, jagged, wet holes . . . wherever down-hole conditions are *tough*.

Plastic Wire Countered Primacord is far less flexible than the Plain and Reinforced types, and its plastic covering is *smooth*. So, play it safe . . . use a continuous, unbroken length in the hole, and attach the down line to the trunk line at a right angle with the loop-lock half-hitch shown here.

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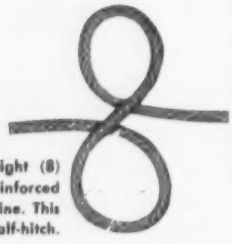
1. Bend a figure eight (8) in the Plain or Reinforced Primacord trunk line. This will be your half-hitch.



2. Loop the end of the Plastic Wire Countered Primacord branch line and pass this loop through the figure eight as shown.

3. Pull the Primacord trunk line *tight* so that the half-hitch grips the doubled-over branch line below the loop.

4. Pass the free end of the branch line Primacord up through the loop as shown above. It can't slip off now!

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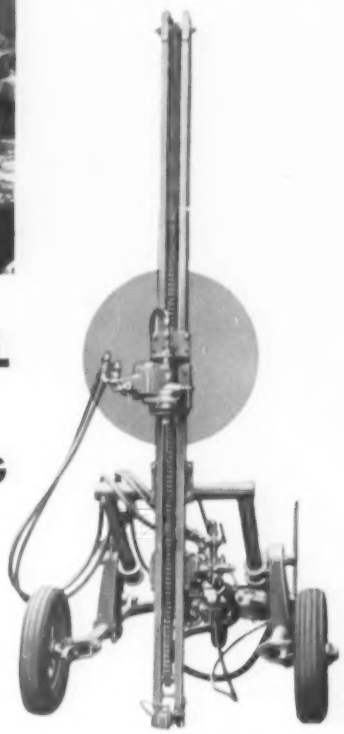
P-23

The new FM-4 is even more rugged and versatile than its famous predecessor, the FM-3, shown here at work on the Connecticut Thruway.

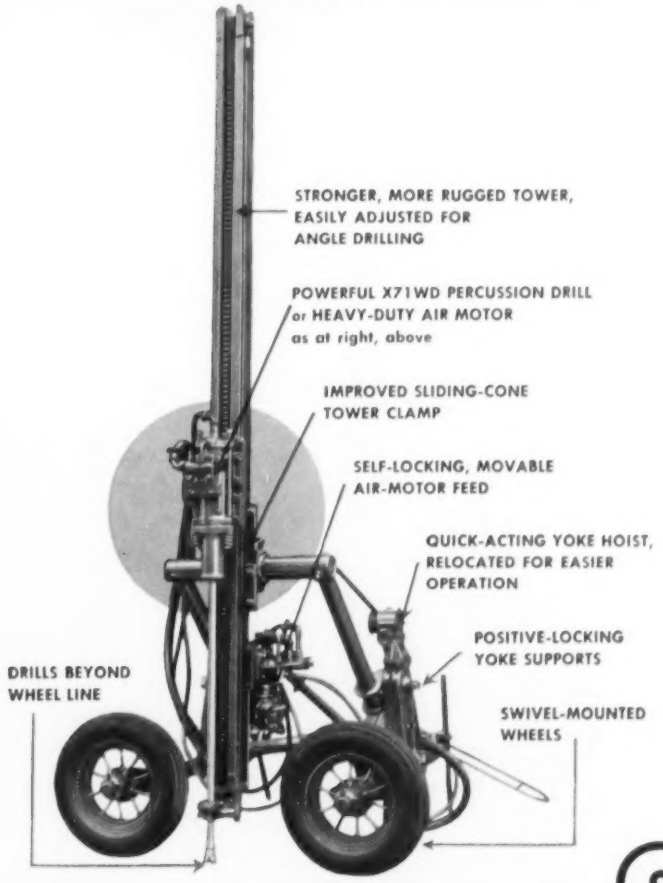
NEW FM-4 WAGON DRILL

now available for

PERCUSSION or ROTARY DRILLING



FM-4 Wagon Drill with air motor for rotary drilling.


STRONGER, MORE RUGGED TOWER, EASILY ADJUSTED FOR ANGLE DRILLING
POWERFUL X71WD PERCUSSION DRILL or HEAVY-DUTY AIR MOTOR as at right, above
IMPROVED SLIDING-CONE TOWER CLAMP
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Now, whether you're drilling hard rock or soft shales and gypsum, you can take full advantage of the dependability, versatility and easy maneuverability of the Ingersoll-Rand FM-4 Wagon Drill.

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